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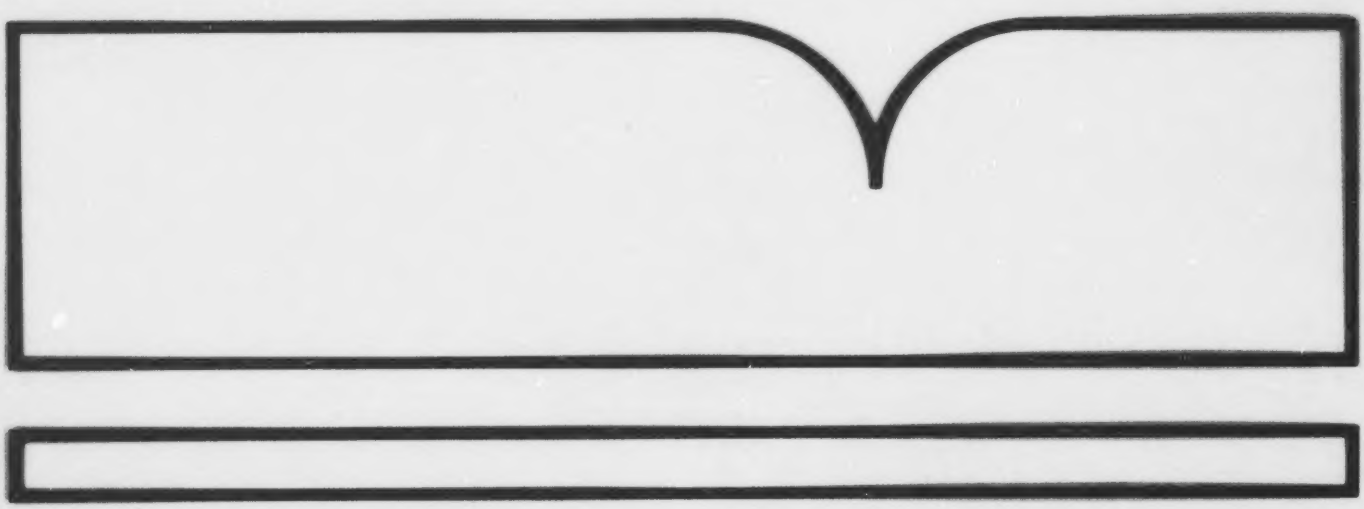

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DEWATERING MUNICIPAL SEWAGE SLUDGES
SELECTING A PROCESS

by

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ABSTRACT

Using information and data obtained for an update of the U.S. Environmental Protection Agency's guidance document on dewatering municipal wastewater sludges, a sequential review of key considerations in selecting an optimum process. Included in the discussion are the principal mechanical dewatering devices now being applied: continuous belt filter presses, solid bowl contrifuges and recessed plate filter presses; their simplicity of operation and their major operational variables. Performance capabilities are also considered and compared with those of other dewatering methods. Selection criteria for a plant's dewatering process are critiqued in light of how the sludge will be disposed of, plant size and ease of the dewatering processes' operation.

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) recently completed a project of data gathering and development to update its guidance document, "Process Design Manual for Dewatering Municipal Wastewater Sludges." Significant advances were made in dewatering technology since preparation of the last manual' and the regulatory climate for disposal of sludges by landfilling, combustion, land application, and ocean disposal has changed. The revised manual considers the upgrading of existing dewatering processes, as well as the designing of new ones, and pays particular attention to the needs of small facilities. All currently employed technologies are considered as well as emerging ones. Specifically discussed are those processes where the most extensive and cost-effective dewatering performance improvements have been made, including air drying, centrifugation, belt press filtration and recessed plate pressure filtration using polymer conditioning.

OBJECTIVE

This paper seeks to accomplish two things. First it discusses the principal mechanical dewatering processes being applied today and their capabilities. Secondly it looks at the criteria for selection of an optimum dewatering process for a particular application.

DEWATERING PROCESS DEFINED

The purpose of dewatering is to remove water and thereby reduce a sludge's volume. This produces a sludge which behaves more as a solid than it does as a liquid and reduces the cost of subsequent treatment and disposal. In most cases, the percent solids content of a dewatered sludge is set by the requirements for subsequent treatment and disposal; this percent solids content is always significantly higher than the percent solids content of a thickened sludge.

MECHANICAL DEWATERING PROCESSES

Conditions favoring the use of mechanical dewatering processes over air drying ones include aesthetics, climate, costs and site limitations. While vacuum filtration remained the most popular method of sludge dewatering into the early 1970s, this practice was sharply curtailed by the end of the decade. No significant improvements in vacuum filtration have occurred recently, and none are currently foreseen. Improvements in belt presses and centrifuges resulted in a shift to these devices; they were more cost effective and generally produced better results than vacuum filtration. The oil shortage in the mid seventies produced a renewed interest in filter presses, especially in combustion operations where fuel costs had increased four to eight-fold in a matter of two to three years. The fact that both belt presses and centrifuges were more efficient in the use of polymers weighed heavily in their favor. Recently, filter press operations have had success with polymers. This development should lead to further interest in filter presses, particularly for composting, combustion and restricted landfills (moisture limited).

Lime and ferric chloride conditioning have become a less favored option than polymer conditioning for several reasons. With these conditioning chemicals, operation and maintenance (O&M) costs are higher and the operation is less clean and more labor intensive. The seventies saw an increase in the cost of lime, as much as 200-300 percent. Further, lime and ferric chloride conditioning increases the gross solids for disposal by 20-25 percent, whereas polymer produces a negligible increase in solids quantity.

It is possible to compare mechanical dewatering devices operating at maximum practical capacity in relative terms to each other in terms of cake solids, chemical costs and solids recovery.

CONTINUOUS BELT FILTER PRESSES

These units squeeze water out of sludge solids. A belt filter press dewatering system applies several steps of processing sludge: chemical conditioning, gravity drainage, low pressure squeezing and high pressure squeezing and shear. Figure 1 shows schematically a continuous belt filter press. In the gravity drainage section, the sludge is spread out on the belt and allowed to drain free for one to two minutes as the porous belt moves slowly into the low pressure squeeze zone. Another continuous belt meets the top of the sludge mat. As rolls apply pressure to belts below and above the mat, more easily removed water is squeezed out. The low pressure roll system includes several rolls, sometimes with decreasing diameters for gradual increase of pressure. The key to good dewatering of wastewater sludge is to raise the squeeze at a gradual rate; otherwise, the soft material will be forced into the mesh of the belt instead of forming a tough mat. This zone is sometimes

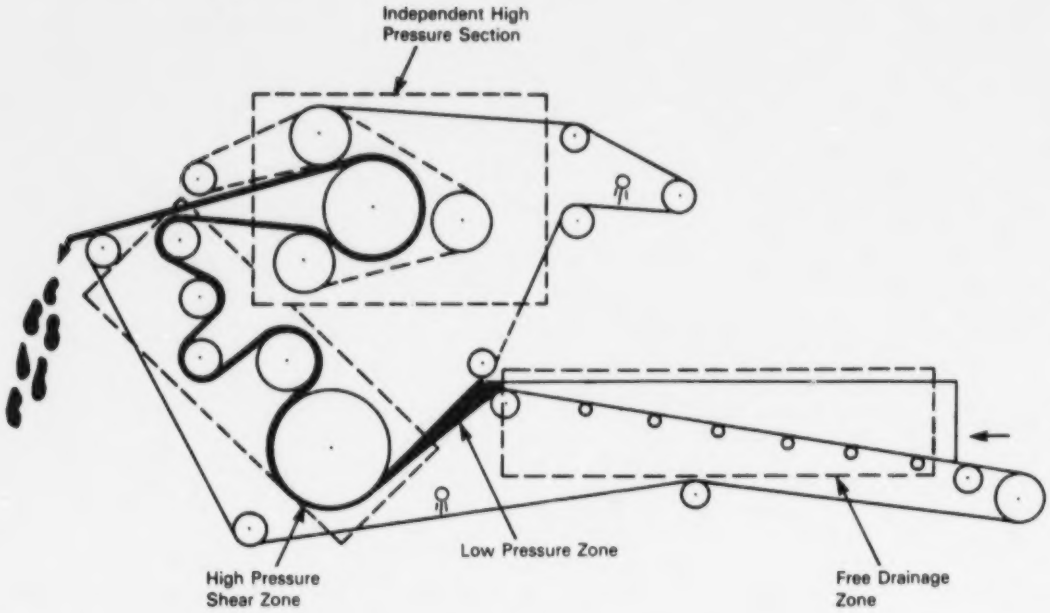

Figure 1
Simplified Schematic of a Belt Filter Press

called the "wedge" zone because the cake mat gets thinner as it passes through.

Water that remains between adjacent particles is squeezed out in the high pressure section, where the particles are forced out of shape and into each other. This shearing action removes some capillary water still clinging to the particles. Some designs use the decreasing-roll-diameter in the high pressure zone, which is called the "shear" zone. Shear is a term describing the action where one belt moves at a different rate than the other, causing a slip tendency in the sludge mat which helps release tightly held capillary water. The release of cake from the belt is aided by two features, a) the flexing of the belt over the discharge roll, and b) a scraper which rides against the belt.

SOLID BOWL CENTRIFUGE

The solid bowl centrifuge, shown in Figure 2, is composed of an outer casing, a cylindrical bowl and a screw conveyor—both supported by pillow block bearings. The bowl and conveyor are driven by a gear and motor or belt and motor assembly. The bowl has a conical section-called a beach at the solids discharge end and a series of holes or weirs at the opposite or centrate discharge end. The bowl and conveyer are rotated so that a centrifugal force of 700-1500 × g will be experienced on the inside of the bowl. Sludge is then introduced into the bowl through openings in the screw and then forms a "pool" against the bowl wall. Separation of the solids takes place within this pool and is due to centrifugal force. The screw conveyer is turning in the same direction as the bowl but at a slightly slower speed, giving the effect of motion from left to right. This motion causes the solids to be scraped towards the beach and up the beach leaving the water behind. The solids are then discharged from the centrifuge. Centrate exits through the weirs at the opposite end of the bowl and is returned to the front end of the plant. These weirs are adjustable in order to control the pool depth and sludge level.

The concurrent flow centrifuge used virtually the same components as the countercurrent type; but, as the name indicates, the sludge and centrate flow are in the same direction rather than in the opposite one as with the countercurrent.

FILTER PRESS

The two types of filter presses which are commonly available to dewater municipal wastewater sludges are the fixed volume recessed plate filter press, also referred to as the diaphragm filter press. In the fixed volume recessed plate filter press, shown in Figure 3, liquid sludge is pumped by high pressure pumps into a volume between two filter cloths, held in place by a rigid framework. As a result of the high pressure that the sludge is under, a substantial portion of the water in the feed sludge passes through the filter cloth and drains from the press. Sludge solids and the remaining water eventually fill the void volume between the filter cloths, and continued pumping of solids to the press is no longer productive. At this point, pumping is stopped and the press is opened to release the dewatered sludge cake prior to initiation of a new cycle. In a variable volume recessed plate or diaphragm filter press, slude is pumped into the press at a low pressure until the volume of the press has been filled with a loosely compacted cake, then sludge pumping

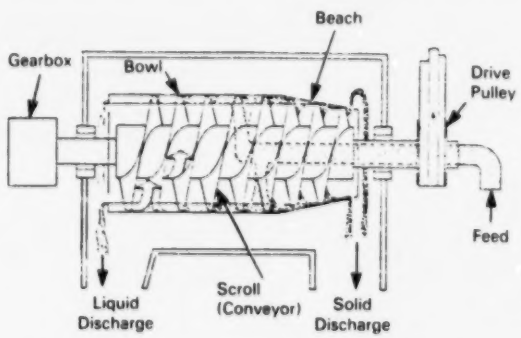

Figure 2
Solid-Bowl (Countercurrent) Conveyor Discharge Centrifuge

is stopped and the diaphragm is inflated for a preset time. For the diaphragm press, although most of the water removal occurs when sludge is being pumped into the press, a significant quantity of water is also removed after the diaphragm is inflated.

KEY OPERATIONAL VARIABLES AFFECTING MECHANICAL DEWATERING PERFORMANCE

Table 1 presents the more significant design and operating variables that impact the performance of the specific dewatering device. These variables affect the rate of production, solids recovery, and cake solids as well as the type and quantity of conditioning chemicals and dewatering aids employed. Table 1 lists only those variables that affect performance and that can be changed in the field and during design of the dewatering station. Variables controlled by the equipment suppliers, such as the bowl angle of a centrifuge have not been included. The table does not include sludge feed rate. If you set the variables shown for a vacuum filter, feed rate is fixed. The same is true for pressure filters. In a belt press, increasing feed rate will flood or starve the filter. In a centrifuge, you can vary feed rate at will—you will just get a more or less dry cake and less or more solids in the centrate. Feed solids concentration has been included since some dewatering processes are more sensitive to feed concentration than others.

CAPABILITIES OF MECHANICAL DEWATERING PROCESSES

In recent years there have been great advances in mechanical dewatering processes. To help the designer sort these processes out, this section of the manual compares the performance of several mechanical dewatering processes. However, communities with adequate land available should also study the air drying alternatives.

Table 1
Operating Variables for Mechanical Dewatering Processes

Vacuum Filter	Recessed Plate
1 Drum Speed/Cycle Time	1 Pressure of Feed Sludge
1 Drum Submergence	1 Filtration Time
1 Sludge Feed Concentration	1 Conditioning Chemicals
2 Quantity of Wash Water Used	2 Use of Precoat
2 Filter Media Used	2 Frequency of Cloth Washing
2 Conditioning Chemicals Type and Dosage	2 Filter Cloth Used
3 Vat Agitation	
Belt Filter Press	Diaphragm Plate Press
1 Belt Speed	1 Diaphragm Pressure
1 Sludge Feed Concentration	1 Conditioning Chemicals
1 Polymer Conditioner	• Type & Dosage
• Type & Dosage	• Point of Addition,
• Dosage	2 Pressure of Feed Sludge
• Point of Addition, Contact Time, Mixing	2 Filtration Time
2 Belt Tension	2 Diaphragm Squeezing Time
2 Belt Type	2 Filter Cloth Used
2 Washwater Flow & Pressure	2 Frequency of Cloth Washing
	2 Sludge Feed Concentration
Solid Bowl Centrifuge	Gravity/Low Pressure Dewatering
1 Bowl/Scroll Differential Speed	1 Polymer Dosage
1 Pool Depth	1 Retention Time
2 Polymer Conditioner	2 Sludge Feed Concentration
• Dosage	2 Belt Speed
• Point of Addition	2 Force Applied By Rollers
2 Mode of Differential Speed Control	2 Depth of Dewatered Sludge in Cylindrical Devices
3 Sludge Feed Concentration	

Legend: 1 Very important variable
2 Significant variable
3 Less important variable

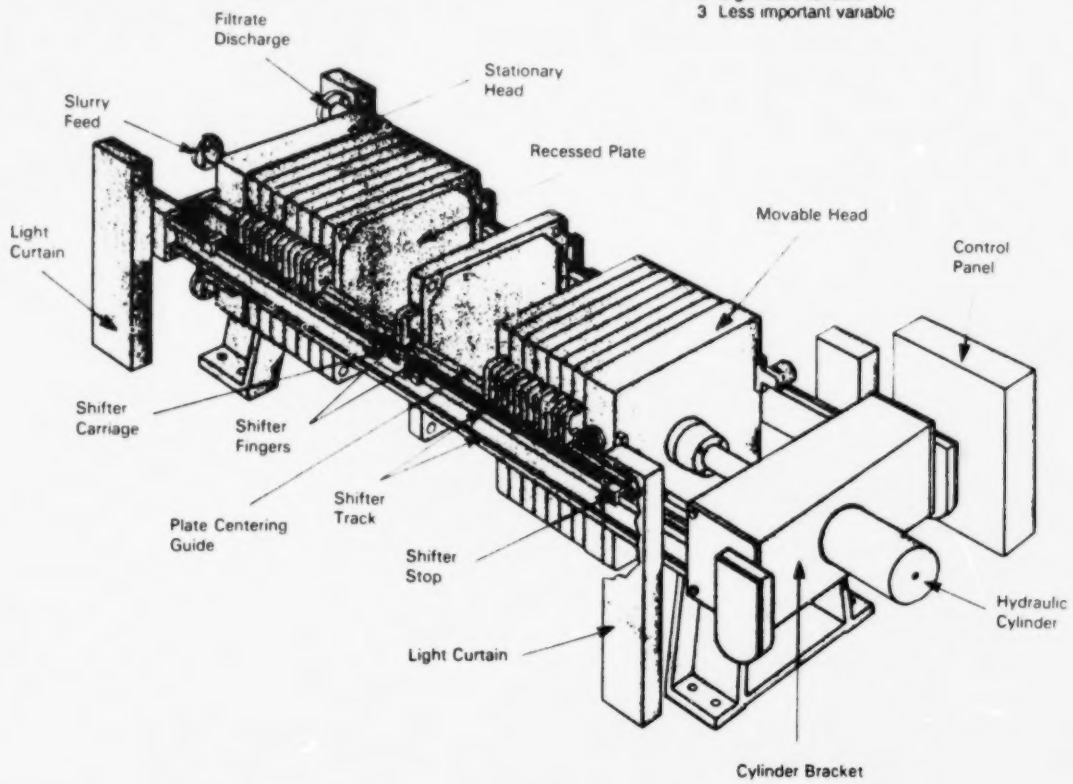

Figure 3
Fixed-Volume Recessed Plate Filter Press
(Courtesy Eimco Process Equipment Co.)

All of the various methods of mechanical sludge dewatering have the capability to produce good recovery (>90 percent) of feed solids and thus the major differentiation is the cake solids content. The capital cost and O&M costs associated with dewatering may be of secondary concern if there is a high cost associated with the water content of the sludge.

The range of cake solids produced by a common type of dewatering process is the result of several factors, the key ones of which are as follows:

a. The ratio of primary to secondary sludge. Inherently, secondary sludge will retain at least twice as much water, kg H_2O/kg total solids (TS), as primary sludge.
b. The origin of the secondary sludge. High SRT (sludge residence time) sludge retains more water than low SRT sludge. Bulking sludges will retain more water than non-bulking sludges.
c. The type and quantity of chemical conditioning can either enhance or reduce the cake solids, depending on the dewatering process employed.
d. The design and age of the dewatering equipment. Older equipment cannot compete with modern (1980 +) designs. Further, there may be several models of the same type of equipment, some of which will produce a drier cake than others. Good examples are the various belt press offerings and the diaphragm recessed plate press vs. the standard recessed plate press.
e. The design and operation of the dewatering stations will significantly impact cake solids content. Dewatering equipment operated at maximum solids capacity may sacrifice 3-5 percentage points in the final product dryness. Drier cakes are produced at reduced operating loadings.
f. Industrial discharges can both enhance or detract from the capability of a dewatering unit. Fibrous discharges, for example, can result in belt presses producing a much drier cake.

Figures 4, 5, and 6 represent typical ranges of cake solids produced by various means of mechanical dewatering. This data is representative of both organic (polymer) and inorganic conditioning; cake solids are not adjusted for ferric chloride and lime addition in these figures. The figures are not recommended or suggested for design purposes and are provided only to indicate the relative capabilities of each type of dewatering unit and the effect of various types of sludges on cake solids. Depending on specific site factors, better or worse results can be achieved.

In Figures 4, 5, and 6, ferric chloride and lime are generally employed for vacuum filters and filter presses. While analyses of cake solids indicate that these cakes are higher in percent TS by 2-5 percentage points than a polymer conditioned sludge from the same device, the water content per unit weight of sludge solids is

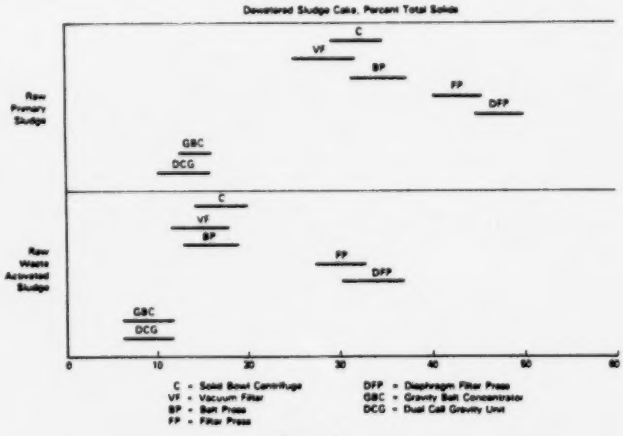

Figure 4
Dewatered Sludge Cake Percent Solids for Raw Primary and Raw Waste Activites Sludges

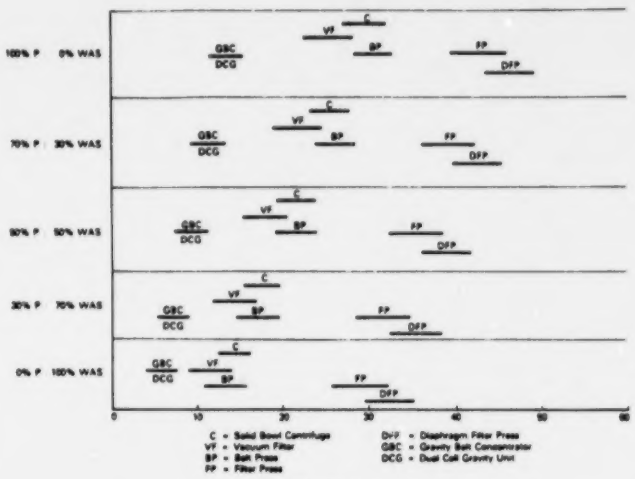

Figure 5
Dewatered Sludge Cake Percent Solids for Mixtures of Digested Primary (P) and Digested Waste Activated Sludges (WAS)

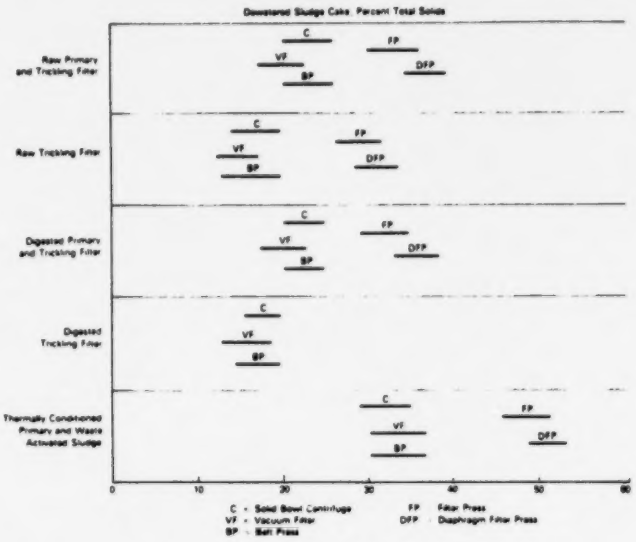

Figure 6
Dewatered Sludge Cake Percent Solids for Mixtures of Raw and Digested Primary and Secondary Sludges and Heat-Treated Primary and Secondary Sludges

about the same. That is, a ferric chloride and lime vacuum filter cake of 23 percent TS would contain the same weight of water/kg sludge as would a polymer conditioned cake of 20 percent TS.

Figure 4 shows the characteristic results achieved when dewatering 100 percent raw primary sludge (RPS) and 100 percent waste activated sludge (WAS) using various kinds of dewatering equipment. If the sludges were dewatered first and mixed after dewatering, the final moisture content of the cake could be calculated from this figure as shown below:

$$\text{Sludge at 60:40 RPS-RWAS} \qquad \%\ \text{TS Mixture} = \frac{(P + WAS)}{\frac{P}{\%\ TS_P} + \frac{P}{\%\ TS_{WAS}}}$$

$$\%\ \text{TS Mixture} = \frac{(60 + 40)}{\frac{60}{30} + \frac{40}{17}} = 23\%\ TS$$

It is necessary to substitute site-specific numbers for the sludge proportion of 60:40 and cake solids for each fraction. These numbers must be consistent with the sludge at the specific site and representative of the capabilities of the equipment supply and process design. This equation can also be used to estimate the moisture content of dewatered cake if the mixing is done before dewatering. The estimate is not conservative; it would be best to carry out dewatering tests on the mixture.

The filter presses (recessed plate and diaphragm plate) will always produce the driest cake solids with the available technology. New dewatering equipment, now in development or an early stage of application may rival the filter presses' ability to produce the driest cake solids. Belt presses and centrifuges both achieve approximately the same cake solids, with the belt press being more appropriate for sludges of higher primary (more structured) content, when highest solids content is required.

Figure 5 provides cake solids content for various methods of dewatering a digested primary and waste activated sludge. Generally, digesting the primary sludge before dewatering results in a slightly wetter cake, probably a result of the finer particles produced by anaerobic decomposition. However, those plants with poor grit removal, and hence a higher proportion of grit in the digested sludge, may produce a drier digested sludge than would be produced if it were dewatered in the raw state.

Mechanical thickening devices such as the Gravity Belt Concentrator and the Dual Cell Gravity Unit produce a much lower solids content than the other dewatering devices. However, their simplicity and ease of operation can be well suited to small plants that either stockpile and/or land spread dewatered sludge.

Figure 6 provides dewatering information for raw and digested trickling filter plant sludges. These sludges behave similarly to an activated sludge plant's waste solids where the sludge ratio is about 65:35 RPS:WAS. Heat treated sludges are often dewatered without chemical conditioners. However, they will require polymers to control the suspended solids recycle with centrifuges and belt presses. Although, dosage will be low—about 20-25 percent of that required for the sludge before thermal treatment.

Some general conclusions can be drawn from Figures 4, 5 and 6. They are:

a. Solid bowl centrifuges and belt presses can produce about the same cake solids. However, belt presses with high pressure attachments can generally produce 2-3 percentage points higher cake solids with sludges of good structural characteristics.
b. The low energy gravity drainage units that produce a cake of a low solids content may be attractive for small plants and where land spreading disposal is practiced.
c. The recessed plate filter presses will produce 6-10 percentage points drier cake than the continuously fed dewatering units; addition of the diaphragm can increase the cake solids content 3-5 percentage points more.
d. In general, digested sludge cakes will have a solids content 2-3 percentage points lower than that of the raw sludge, with the exception of those with a low volatile content due to grit.
e. The range in cake solids from plant to plant will be quite wide due to specific site conditions and design and operating factors.

MATCHING THE DEWATERING PROCESS & PLANT

When either evaluating or selecting a dewatering process, one must keep in mind the inherent influence of both the prior wastewater and sludge treatment processes as well as the subsequent use of disposal practices. A dewatering process cannot be evaluated without considering the other processes involved in the overall wastewater/solids handling system. This evaluation or selection can be a complex procedure because of the large number of possible combinations of unit processes available for wastewater treatment and sludge thickening, stabilization, conditioning, dewatering and ultimate use/disposal. Figure 7 shows the unit processes most commonly used to perform most of these functions.

OPERATIONAL SELECTION CRITERIA

The criteria employed for selecting a sludge dewatering process are complex and will vary from site to site and with the size of the plant. Given similar circumstances, engineers will often select different dewatering processes based on their past experiences and personal preferences. Often there is more than one correct process selection, or the correct selection could only be established by exhaustive testing and engineering economic analysis.

The selection criteria for smaller plants are considerably different than those for larger facilities. In many cases, other considerations, such as transport and land availability, may have a more significant impact than economics. Table 2 presents various selection criteria versus plant size. However, site-specific conditions may change the relative importance of some of the criteria. For example, a drying bed in a highly developed area would be more objectionable than it would be in a semi-rural setting or in a heavily industrialized area.

The classification of plants as small (<2 mgd or <0.08 m^3/s), medium (2-10 mgd or 0.08-0.44 m^3/s) and large (>10 mgd or >0.44 m^3/s) is rather arbitrary and is used merely as a generalization to segment applicable technology. The personnel at a 0.11 m^3/s advanced wastewater treatment plant treating wastewaters to 5 mg/l BOD_5, 5 mg/l TSS, 1 mg/l NH_4N, and 1 mg/l total phos-

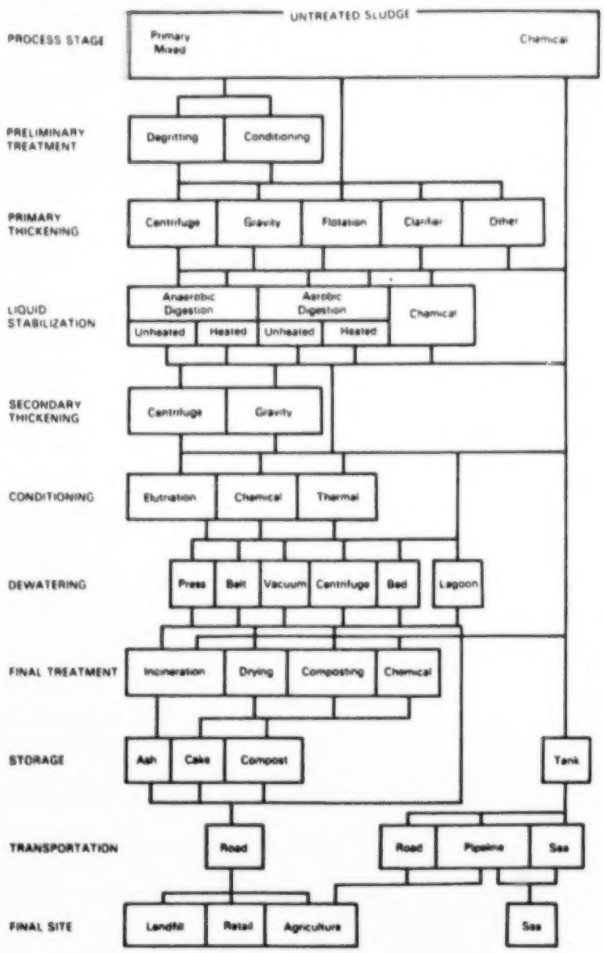

Figure 7
Sludge Processing Options

Table 2
Operational Selection Criteria for Sludge Dewatering Processes

Plant Size	Key Criteria
Small < 0.08 m^3/s (< 2 mgd)	Minimum Mechanical Complexity Local Repairs and Parts Minimum Operator Attendance Reliable Without Skilled Service Unaffected by Climatic Factors Large Excess Capacity Handleable Cake
Medium 0.08 - 0.44 m^3/s (2 - 10 mgd)	Low Operator Attendance Local Repair and Parts Transportable Cake Without Nuisance Mechanical Reliability Competitive O&M Costs Drier Cake
Large > 0.44 m^3/s (> 10 mgd)	Lowest O&M Costs/ton Dry Solids Lowest Capital Costs/ton Dry Solids Driest Cake High Output/Unit Mechanical Reliability Transportable Cake Without Nuisance

General Considerations

- Compatibility with existing equipment with long-term sludge disposal
- Long-term serviceability/utility
- Acceptable environmental factors
- Good experience at other operating installations
- Competence and quality of local operator and service personnel
- Compatibility with plant size
- Acceptance by user and regulatory agency
- Availability and need of manufacturer's services

phorus may be much more qualified to operate and maintain a mechanical dewatering unit than the personnel at a 0.53 m^3/s plant using trickling filters to meet 30/30 criteria. The anticipated quality and quantity of the O&M staffing are important criteria for the engineer to consider in the selection of process technology.

In smaller plants, the lowest initial cost may not be the best selection if it required continuous operator attendance, is mechanically complex, and cannot be repaired locally. The impact of these considerations can easily offset the advantage of an alternative lower cost dewatering process. A mechanical dewatering process that is operating at 200 kg dry solids/hr, but requires continuous operator attention, could result in over $50/ton operating labor costs plus the maintenance costs.

PROCESS COMPATIBILITY WITH SIZE OF PLANT

Use of uncomplicated sludge handling systems increases the chance for successful operation in any size of plant. Complex equipment is especially unsuited to small plants for several reasons. First, the amount of operator time available generally decreases as plant size decreases. Second, small plants may not have operations and maintenance personnel with the required skills. Third, less complicated equipment is generally less expensive to purchase. Since standby capacity of about 100 percent is often provided for small plants (usually with duplicate units rather than employing a single large unit), it is more economical to choose the less complicated, less expensive system.

Generalized guidance to selection of a dewatering process based on results at plants across the United States is summarized in Table 3, which presents compatibility of different dewatering techniques with various plant sizes. Designers should use the information presented in Table 3 only as a guide. Every plant must be considered independently, since site-specific considerations can have a large influence on the dewatering process. For example, drying beds and sludge lagoons may be cost-effective at a plant larger than 0.44 m^3/s (10 mgd), if weather is favorable and land available. Using a structured approach to evaluate the alternatives, in conjunction with the costs of the ultimate solids disposal method, will sort out the appropriate technology.

Table 3
Compatibility of Dewatering Process with Plant Size

	Plant Size, m^3/s		
	< 0.04	0.04-0.44	> 0.44
Belt and Drum Thickeners	X[1]	X	X
Solid Bowl Centrifuge		X	X
Belt Filter Press	X[2]	X	X
Vacuum Filter		X	X
Filter Press		X	X
Drying Beds	X	X	
Sludge Lagoons	X	X	

[1] Suitable for land spreading or injection of sludge.
[2] Only low pressure press is commonly used in this flow range.

PROCESS COMPATIBILITY WITH THE ULTIMATE DISPOSAL TECHNOLOGY

The ultimate disposal method chosen for the residual solids often dictates the process selection. The most common methods of disposing of the cake are shown in Table 4. The end-product of each dewatering method is rated in terms of the product's acceptability vis-a-vis the ultimate disposal of the residuals. However, this table is not meant to establish the compatibility of the dewatering process and the end-disposal means. For example, combustion of a sand bed product of 30-40 percent TS is very economical, but the use of sand beds to dewater sludge solids for combustion may be impractical. On the other hand, a compost operation may be better equipped to process the periodic and somewhat variable sand bed product which can be stockpiled until needed.

Table 4
Suitability of Cake Produced by Dewatering Processes for Various Ultimate Disposal Options

Dewatering Process	Cake Solids %	Land Spread	Land Spread Injection	Landfill	Combination Drying	Compost
Lagoon	15 - 40	1		2	3	2
Sand Beds	30 - 60	1		1	1	1
Vacuum Assisted Beds	10 15	1 2		3 2/1	3 3	3 2
Screw Press	12 20	1 2		3 2	3 3	3 2
Paved Beds	30 - 60	1		1	1	1
Belt Press	18 24	2 2		2 2	3 2	2 2
Centrifuge	18 24 5 7	2 2 1	1	2 2 3	3 2 3	2 2 3
Vacuum Filter	18 - 20	2		2	3	2
Filter Press	28 34	1 1		1 1	2 1	2 1
Drum/Belt Thickeners	5 - 8	1	1	3	3	3

Key: 1 Good
2 Satisfactory
3 Inappropriate
Note: The ratings apply to the product characteristics and not the methodology employed to achieve the cake solids.

While all sludge cakes meeting EPA's stability regulations can be land spread, drier solids will be easier and less costly to transport and apply to the land. The drier the cake, the less the probability of any nuisances such as odors, insects, or liquid runoff. Ideally, sludge applied to land should either be sufficiently dry so that the spreader can break it into small pieces or should be a liquid that can be evenly spread. Injection of liquid sludge can eliminate nuisances, but it also can be limited by weather conditions. If the land is to be "worked" after the sludge application, then the cake solids concentration is less of a concern, except where the sludge cake must be stored for part of the year. In this case, a drier cake is preferred.

Landfill operations are becoming more selective in the materials accepted. Wet cakes, which may result in liquid discharges, are particularly discouraged. A minimum cake of 18 percent TS is considered acceptable for a narrow trench landfill. However, higher percent TS may be required in some areas of the United States, and in the future higher percent TS may be required in many areas. West Germany currently required 35-40 percent TS for landfill.

Dewatering of sludge for combustion or drying requires that the solids content be equal to 24 percent TS, preferably 28-30 percent for an economical operation. On a typical raw primary sludge (60 percent) and WAS (40 percent) mixture, only drying beds and filter presses can reliably deliver 24 percent TS or drier cakes. While many multiple hearth furnaces (MHF) in the United States can burn 24-25 percent TS sludge cakes autogenously, the stack outlet gases are below 480°C (900°F). Some new state regulations now require a 650-760°C (1,200-1,400°F) stack outlet temperature to ensure deodorization. Fluid bed reactors (FBR) require about 28 percent TS with heat exchangers to preheat the air and 34 percent TS without heat exchangers to burn raw primary and waste activated sludge autogenously. Combustion gases from FBR units always exceed 800°C (1,470°F) due to process configuration.

Compost operations can sometimes suffer even more than combustion from wet cakes. This is particularly true in colder, wetter regions and where the compost piles are not protected from the elements. Since it is important to maintain the compost in a specific moisture and temperature range, it is necessary to recycle the drier product to bulk the sludge cake and to reduce the average moisture content. The wetter the cake, the higher the recycle or new bulking agent, the more the pile is cooled and the less economical. At some point, further dewatering may have very little benefit, since the bulking requirements for air flow may govern.

CONCLUSION

No simple way exists for selecting the best dewatering process for a municipal wastewater treatment plant. This paper is able, however, to compare capabilities of the various dewatering processes. It further, for a given plant, suggests dewatering processes as a function of the plant's chosen method for ultimate sludge disposal, its capacity and its operation and maintenance capability.

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